U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-256 550

Greenwood Lake, Passaic County, New Jersey and Orange County, New York

National Environmental Research Center

Prepared For
Pacific Northwest Environmental Res. Lab.

May 1976

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Greenwood Lake, Passaic County, New Jersey and Orange County, New York		5. REPORT DATE Prepared May 1976 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper No. 367
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency P.O. Box 15027 Las Vegas, NV 89114		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1973 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, Corvallis Environmental Research Laboratory, Eutrophication Survey Branch, Corvallis, OR 97330

16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C
		PRICES SUBJECT TO CHANGE
18. DISTRIBUTION STATEMENT Release unlimited	19. SECURITY CLASS (This Report)	21. NO. OF PAGES 42
	20. SECURITY CLASS (This page)	22. PRICE $4.00

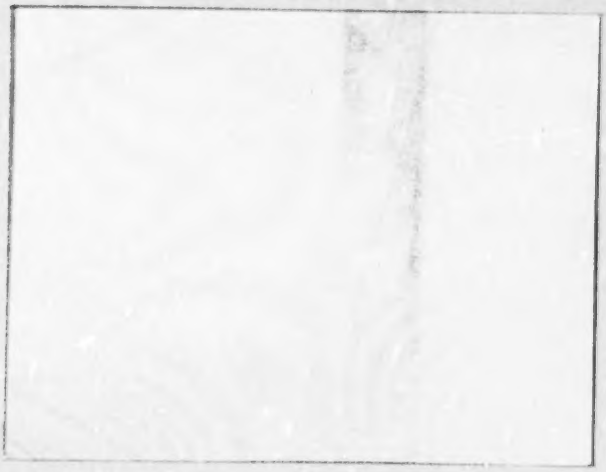
EPA Form 2220-1 (9-73)

243040

PB 256 550

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 699-440

REPORT

ON

GREENWOOD LAKE

PASSAIC COUNTY, NEW JERSEY

ORANGE COUNTY, NEW YORK

EPA REGION II

WORKING PAPER No. 367

WITH THE COOPERATION OF THE

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

AND THE

NEW JERSEY NATIONAL GUARD

MAY 1976

CONTENTS

	Page
Foreword	ii
List of Study Lakes - State of New Jersey	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	14
VI. Appendices	15

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the New Jersey Department of Environmental Protection for professional involvement and to the New Jersey National Guard for conducting the tributary sampling phase of the Survey.

Douglas Clark, Chief of the Bureau of Water Quality Planning and Management, Mr. Frank Takacs, New Jersey National Eutrophication Survey Coordinator, Principal Environmental Specialist, and Robert Kotch, Senior Environmental Engineer, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

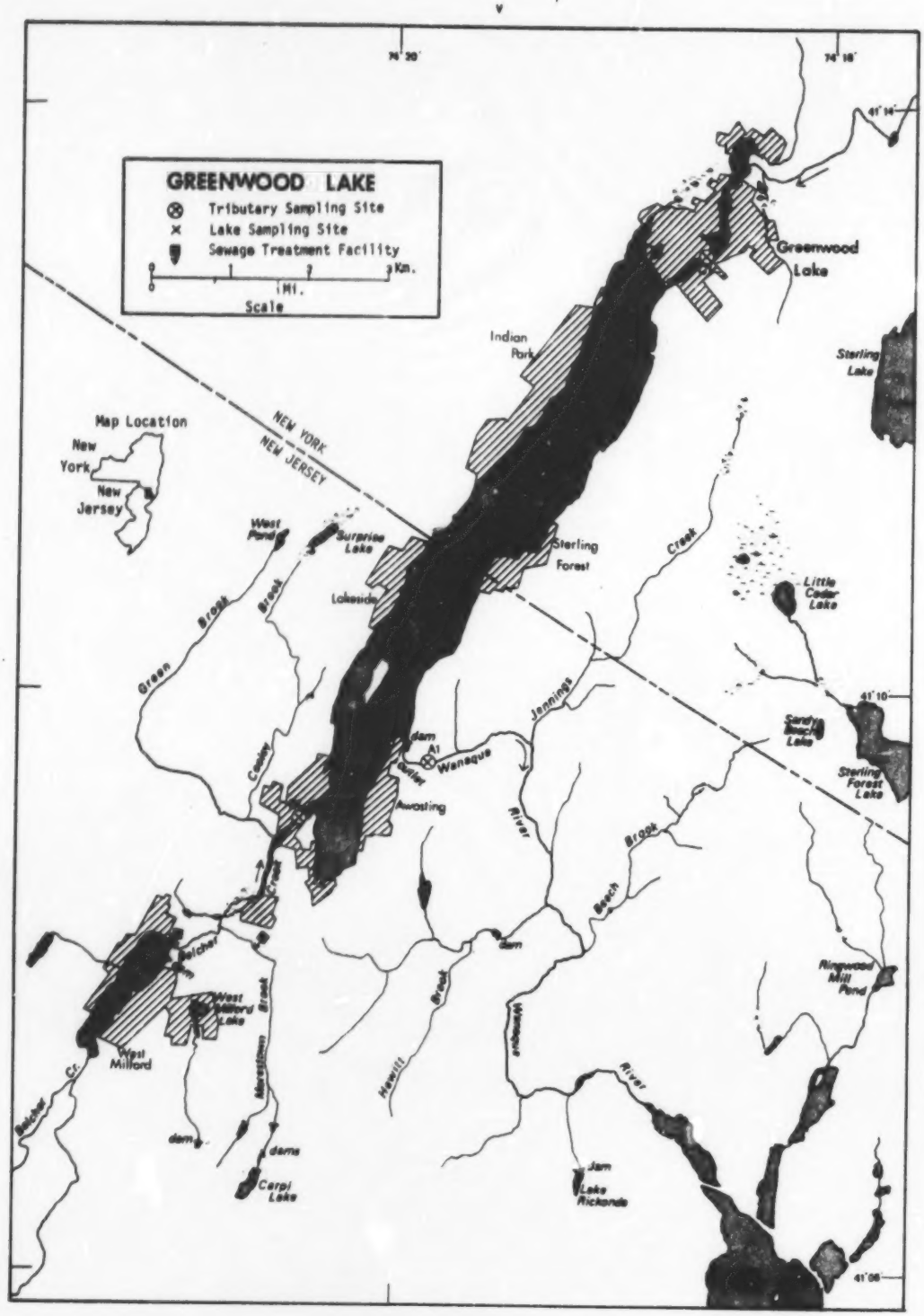
Major General William R. Sharp, Former Chief of Staff, Major General Wilfred G. Menard, Jr., Chief of Staff, and Project Officer Colonel Herbert D. Ruhlin, who directed the volunteer efforts of the New Jersey National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF NEW JERSEY

LAKE NAME	COUNTY
Budd Lake	Morris
Duhernal Lake	Middlesex
Farrington Lake	Middlesex
Greenwood Lake	Passaic, N.J.; Orange, N.Y.
Lake Hopatcong	Morris, Sussex
Lake Musconetcong	Morris, Sussex
Oradell Reservoir	Bergen
Paulinskill Lake	Sussex
Pinecliff Lake	Passaic
Pompton Lakes	Passaic
Spruce Run Reservoir	Hunterdon
Union Lake	Cumberland
Wanaque Reservoir	Passaic


GREENWOOD LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Scale
Map Location
New York
New Jersey
NEW YORK
NEW JERSEY
Greenwood Lake
Indian Park
Sterling Lake
Sterling Forest
Surprise Lake
West Pond
Lakeside
Little Cedar Lake
Jennings
Awosting
Wanaque
River
Ringwood Mill Pond
West Milford
West Milford Lake
Clinton
Macopin
Hewitt
Wanaque
Jam
Lake Rickards
Carpi Lake
74°20'
74°15'
41°14'
41°10'
41°05'

GREENWOOD LAKE, NEW JERSEY

STORET NO. 3403

I. CONCLUSIONS

A. Trophic Condition:

Based upon field observations and Survey data, Greenwood Lake is considered early eutrophic. The lake is characterized by summer depression of dissolved oxygen content, high total phosphorus levels and abundant submerged and emerged aquatic vegetation. Chlorophyll a values ranged from a low of 5.1 µg/l in the fall to a high of 20.6 µg/l in the summer. Mean Secchi disc transparency was 217.8 cm.

In the past, herbicidal control has been practiced annually or biannually. Ketelle and Uttormark (1971) recommended partial dredging and removal of controllable nutrient sources for future control.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Greenwood Lake was limited by available phosphorus. Spikes with phosphorus or nitrogen and phosphorus simultaneously resulted in increased assay yields. The addition of nitrogen alone did not stimulate a growth response.

The ratio of mean total inorganic nitrogen to mean orthophosphorus (N/P) in lake waters during spring sampling substantiates these results, but indicates nitrogen limitation during summer and fall.

C. Nutrient Controllability:

1. Point Sources -

The mean annual phosphorus load from point sources was estimated to be 13.4% of the load reaching Greenwood Lake. The Birch Hill Park Disposal Co. contributed 10.5% of the total load. The nutrient loading to Greenwood Lake of 0.31 $g/m^2/yr$ was 1.4 times greater than the "permissible" load proposed by Vollenweider (Vollenweider and Dillon, 1974), and was about 1.5 times below his proposed "dangerous" load. Total elimination of known point sources would result in a drop of the loading rate and should gradually improve the water quality of the lake.

2. Non-point Sources -

Non-point sources contribute 86.6% of the phosphorus loading reaching Greenwood Lake. Measured tributaries contributed 40.7% of the total phosphorus load and ungaged drainage areas were estimated to contribute 20.9% of the load.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. The lake surface area and mean depth were provided by the State of New Jersey. Tributary flow data were provided by the New Jersey District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by the mean flow of the outlet. Precipitation values were estimated by methods as outlined in National Eutrophication Survey (NES) Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morphometry:

1. Surface area: 7.77 km^2.
2. Mean depth: 5.2 meters.
3. Maximum depth: 17.4 meters
4. Volume: 40.404 x 10^6 m^3.
5. Mean hydraulic retention time: 346 days.

B. Tributary and Outlet (see Appendix B for flow data):

1. Tributaries -

Name	Drainage area (km^2)	Mean flow (m^3/sec)
B(1) Belcher Creek	37.6	0.83
C(1) Unnamed Creek	13.4	0.24
Minor tributaries and immediate drainage -	11.4	0.35
Totals	62.4	1.42
2. Outlet - A(1) Wanaque River	70.2	1.35

C. Precipitation:

1. Year of sampling: 122.9 cm.

2. Mean annual: 156.4 cm.

III. LAKE WATER QUALITY SUMMARY

Greenwood Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake (Station 1 was sampled once, Stations 2 through 4 were sampled three times) and from one or more depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 1.5 meters at Station 1, 14.9 meters at Station 2, 8.5 meters at Station 3, and 1.5 meters at Station 4. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III B. Results of the limiting nutrient study are presented in III C.

GREENWOOD LAKE
STORET CODE 3403

PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	N*	(4/16/73) S*** = 4 RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	N*	(7/23/73) S*** = 3 RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	N*	(10/ 1/73) S*** = 3 RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	5	8.9- 10.0	9.4	0.0- 1.5	6	25.0- 26.4	25.8	0.0- 1.5	5	19.5- 19.7	19.7	0.0- 1.5
MAX DEPTH**	4	7.7- 9.9	9.8	0.0- 14.9	3	12.6- 25.7	14.5	1.5- 12.2	3	14.1- 19.7	19.1	0.0- 10.4
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	2	12.0- 12.3	12.1	0.0- 1.5	3	7.6- 9.8	8.8	0.0- 1.5	3	8.8- 9.4	8.4	0.0- 1.5
MAX DEPTH**	4	11.9- 12.3	12.0	0.0- 14.9	3	0.3- 7.6	1.2	1.5- 12.2	3	0.4- 9.4	6.8	0.0- 10.4
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	5	92.- 100.	95.	0.0- 1.5	6	92.- 94.	94.	0.0- 1.5	5	180.- 200.	190.	0.0- 1.5
MAX DEPTH**	4	92.- 95.	92.	0.0- 14.9	3	80.- 94.	89.	1.5- 12.2	3	180.- 220.	180.	0.0- 10.4
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	5	7.6- 8.2	7.9	0.0- 1.5	4	6.9- 7.6	7.2	0.0- 1.5	5	6.5- 7.1	6.8	0.0- 1.5
MAX DEPTH**	4	7.6- 8.1	7.6	0.0- 14.9	3	6.3- 6.9	6.6	1.5- 12.2	3	6.3- 6.8	6.4	0.0- 10.4
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	5	15.- 20.	15.	0.0- 1.5	4	16.- 21.	20.	0.0- 1.5	5	12.- 15.	12.	0.0- 1.5
MAX DEPTH**	4	15.- 20.	16.	0.0- 14.9	3	21.- 28.	21.	1.5- 12.2	3	11.- 25.	15.	0.0- 10.4
TOTAL P (MG/L)												
0.-1.5 M DEPTH	5	0.016-0.021	0.016	0.0- 1.5	3	0.022-0.043	0.040	0.0- 1.5	5	0.019-0.033	0.023	0.0- 1.5
MAX DEPTH**	4	0.018-0.021	0.020	0.0- 14.9	2	0.035-0.043	0.039	1.5- 8.5	3	0.033-0.191	0.056	0.0- 10.4
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	5	0.004-0.011	0.006	0.0- 1.5	4	0.006-0.011	0.008	0.0- 1.5	5	0.005-0.010	0.006	0.0- 1.5
MAX DEPTH**	4	0.005-0.011	0.007	0.0- 14.9	3	0.007-0.120	0.009	1.5- 12.2	3	0.005-0.062	0.010	0.0- 10.4
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	5	0.050-0.070	0.070	0.0- 1.5	4	0.040-0.040	0.040	0.0- 1.5	5	0.010-0.040	0.020	0.0- 1.5
MAX DEPTH**	4	0.050-0.070	0.070	0.0- 14.9	3	0.040-0.110	0.040	1.5- 12.2	3	0.020-0.020	0.020	0.0- 10.4
AMMONIA (MG/L)												
0.-1.5 M DEPTH	5	0.040-0.070	0.050	0.0- 1.5	4	0.060-0.070	0.060	0.0- 1.5	5	0.030-0.040	0.040	0.0- 1.5
MAX DEPTH**	4	0.030-0.070	0.055	0.0- 14.9	3	0.060-0.560	0.170	1.5- 12.2	3	0.040-0.510	0.050	0.0- 10.4
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	5	0.200-0.600	0.500	0.0- 1.5	3	0.600-0.900	0.700	0.0- 1.5	5	0.400-1.000	0.800	0.0- 1.5
MAX DEPTH**	4	0.200-0.500	0.400	0.0- 14.9	2	0.500-0.600	0.550	1.5- 8.5	3	0.500-1.000	0.800	0.0- 10.4
SECCHI DISC (METERS)	2	1.5- 2.1	1.8		3	1.5- 2.7	2.7		3	1.4- 2.7	2.7	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera		Algal Units per ml
04/16/73	1.	Asterionella	3,099
	2.	Flagellates	1,439
	3.	Fragilaria	1,185
	4.	Synedra	931
	5.	Melosira	457
		Other genera	1,795
		Total	8,906
10/01/73	1.	Flagellates	455
	2.	Melosira	227
	3.	Anabaena	178
	4.	Centric diatom	130
	5.	Tabellaria	114
		Other genera	309
		Total	1,413

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/liter)
04/16/73	1	12.4
	2	16.7
	3	16.4
	4	10.5
07/23/73	2	12.1
	3	9.9
	4	20.6
10/01/73	2	5.2
	3	5.1
	4	10.3

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike(mg/l)	Ortho P Conc.(mg/l)	Inorganic N Conc.(mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.203	1.5
0.05 P	0.060	0.203	4.4
0.05 P + 1.0 N	0.060	1.203	15.1
1.00 N	0.010	1.203	2.0

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary productivity in Greenwood Lake was moderately high at the time of sampling. The lake was phosphorus limited at that time as indicated by the increased growth of the test alga in response to an addition of phosphorus. Spikes with nitrogen and phosphorus simultaneously resulted in a maximum yield while the addition of nitrogen alone did not stimulate growth.

The N/P ratio of 20/1 in the spring lake data further indicates phosphorus limitation. However, N/P ratios in Greenwood Lake during summer and fall were 10/1 and 8/1, respectively, suggesting nitrogen limitation at those times.

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the New Jersey National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in July 1973, and was completed in June 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the New Jersey District Office of USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual concentrations in Unnamed Creek at Station C(1) and mean annual ZZ flows.

The operators of the Birch Hill Park and Marshall Hill School wastewater treatment plants provided monthly effluent samples. Nutrient loads for the plants were calculated using the available monthly chemistry and flow estimates (0.3785 m^3/capita/day).

A. Waste Sources:

1. Known municipal -

Name	Population Served*	Treatment	Mean Flow ($m^3/d \times 10^3$)**	Receiving Water*
Birch Hill Park Disposal Co.	260	1.	0.098	Belcher Creek
Marshall Hill School	160	2.	0.060	Morestown Brook/ Belcher Creek

2. Known industrial - None.

Key: 1. Activated sludge
2. Sand filter

*Treatment plant questionnaires.
**Flow estimate based on 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
B(1) Belcher Creek	660	27.1
C(1) Unnamed Creek	330	13.6
b. Minor tributaries and immediate drainage (nonpoint load) -	510	20.9
c. Known municipal STP's -		
Birch Hill Park	255	10.5
Marshall Hill School	70	2.9
d. Septic tanks* -	475	19.5
e. Known industrial - None		
f. Direct precipitation**-	135	5.5
Total	2,435	100.0

2. Output - A(1) Wanaque River 1,230

3. Net annual P accumulation 1,205

*Estimate based on the population of Greenwood Lake Village (2,200) and 796 homes at Indian Park, Lakeside, and Sterling Forest.

**Estimated (see NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
B(1) Belcher Creek	14,700	23.4
C(1) Unnamed Creek	7,960	12.7
b. Minor tributaries and immediate drainage (nonpoint load) -	12,330	19.6
c. Known municipal STP's -		
Birch Hill Park	1,130	1.8
Marshall Hill School	395	0.6
d. Septic tanks* -	17,860	28.5
e. Known industrial - None		
f. Direct precipitation** -	8,390	13.4
Total	62,765	100.0

2. Output - A(1) Wanaque River 27,000

3. Net annual N accumulation 35,765

*Estimate based on the population of Greenwood Lake Village (2,200) and 796 homes at Indian Park, Lakeside, and Sterling Forest.
**Estimated (see NES Working Paper No. 175).

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
B(1) Belcher Creek	18	391
C(1) Unnamed Creek	25	594

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Yearly Phosphorus Loading (g/m²/yr)
Estimated loading for Greenwood Lake	0.31
Vollenweider's "dangerous" or eutrophic loading	0.46
Vollenweider's "permissible" or oligotrophic loading	0.23

V. LITERATURE REVIEWED

Ketelle, M. J. and P. D. Uttormark. 1971. Problem Lakes in the United States. U.S. Environmental Protection Agency Project #16010 EHR. University of Wisconsin, Madison, Wisconsin.

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, and Corvallis Environmental Research Laboratory, Corvallis, Oregon.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NEW JERSEY 06/04/76

LAKE CODE 3403 GREENWOOD LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 70.2

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3403A1	70.2	1.47	2.04	3.00	2.10	1.42	1.10	0.42	0.91	0.42	0.51	1.33	1.50	1.35
340381	37.6	0.99	0.99	1.67	1.36	0.85	0.51	0.40	0.42	0.42	0.51	0.85	1.02	0.83
3403C1	13.4	0.283	0.283	0.510	0.453	0.278	0.150	0.110	0.110	0.088	0.108	0.212	0.283	0.239
3403ZZ	19.2	0.42	0.42	0.74	0.65	0.40	0.22	0.16	0.16	0.12	0.16	0.31	0.42	0.35

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 70.2
SUM OF SUB-DRAINAGE AREAS = 70.2

TOTAL FLOW IN = 17.84
TOTAL FLOW OUT = 16.23

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3403A1	7	73	2.747	21	0.934				
	8	73	0.396	26	0.159				
	9	73	0.147	23	0.150				
	10	73	0.127						
	11	73	0.340	4	0.396				
	12	73	5.578	8	1.897				
	1	74	2.322	26	3.171				
	2	74	1.671	23	2.917				
	3	74	2.289	23	3.794				
	4	74	3.256	21	2.265				
	5	74	1.586	12	1.246				
	6	74	0.850	22	1.104				
340381	7	73	0.651	21	0.708				
	8	73	0.215	26	0.127				
	9	73	0.133	23	0.227				
	10	73	0.278						
	11	73	0.278	4	0.278				
	12	73	1.982	8	0.538				
	1	74	1.218	26	1.472				
	2	74	0.986	23	2.464				
	3	74	1.416	23	2.067				
	4	74	1.699	21	1.104				
	5	74	1.019	12	1.756				
	6	74	0.481	22	0.453				

TRIBUTARY FLOW INFORMATION FOR NEW JERSEY 06/04/76

LAKE CODE 3403 GREENWOOD LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3403C1	7	73	0.311	21	0.201				
	8	73	0.059	26	0.025				
	9	73	0.020	23	0.025				
	10	73	0.042						
	11	73	0.045	4	0.054				
	12	73	0.793	8	0.161				
	1	74	0.453	26	0.538				
	2	74	0.311	23	0.566				
	3	74	0.425	23	0.651				
	4	74	0.623	21	0.425				
	5	74	0.340	12	0.566				
	6	74	0.113	22	0.085				
3403ZZ	7	73	0.425	21	0.283				
	8	73	0.085	26	0.037				
	9	73	0.031	23	0.034				
	10	73	0.059						
	11	73	0.062	4	0.076				
	12	73	1.133	8	0.229				
	1	74	0.651	26	0.765				
	2	74	0.425	23	0.821				
	3	74	0.623	23	0.934				
	4	74	0.878	21	0.595				
	5	74	0.453	12	0.793				
	6	74	0.164	22	0.122				

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 76/06/04

340301
41 13 03.0 074 18 03.0 3
GREENWOOD LAKE
34031 NEW JERSEY
013292

11EPALES 2111202
0009 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	13 00	0000	10.0			100	8.20	15	0.060	0.500	0.070	0.006
	13 00	0005	9.9	12.3		92	8.10	15	0.040	0.200	0.070	0.005

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	13 00	0000	0.016	12.4
	13 00	0005	0.019	

STORET RETRIEVAL DATE 76/06/04

340302
41 12 07.0 074 18 26.0 3
GREENWOOD LAKE
34031 NEW JERSEY
013292

11EPALES 2111202
0053 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	13 20	0000	8.9		84	95	7.90	15	0.050	0.600	0.070	0.007
	13 20	0006	9.0	12.9		98	7.90	15	0.040	0.400	0.060	0.004
	13 20	0015	9.0	12.4		100	7.90	14	0.050	0.400	0.060	0.006
	13 20	0025	8.3	12.2		92	7.80	14	0.040	0.400	0.060	0.008
	13 20	0035	8.1	12.2		98	7.70	15	0.040	0.300	0.060	0.003
	13 20	0049	7.7	11.9		92	7.60	15	0.070	0.300	0.070	0.005
73/07/23	17 30	0000	25.5	9.8	108	93	7.20	16	0.060		0.040	0.004
	17 30	0005	25.8			92						
	17 30	0010	24.9			91						
	17 30	0015	24.6	6.4		90	6.20	16	0.100		0.110	0.009
	17 30	0020	23.7			84						
	17 30	0025	19.5	1.2		80	6.20	17	0.110	0.400	0.110	0.008
	17 30	0030	14.2	0.2		75	6.50	21	0.210	0.500	0.120	0.026
	17 30	0035	13.3			80						
	17 30	0040	12.6	0.3		89	6.60	28	0.560		0.110	0.120
73/10/01	14 15	0000	19.7		107	200	7.10	12	0.040	1.000	0.040	0.005
	14 15	0005	19.6	8.0		200	6.80	13	0.040	0.800	0.020	0.006
	14 15	0015	19.5	8.0		190	6.50	12	0.030	0.400	0.020	0.006
	14 15	0028	18.9	7.6		190	6.60	11	0.050	0.300	0.020	0.008
	14 15	0034	14.1	0.4		220	6.30	25	0.510	1.000	0.020	0.062

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	13 20	0000	0.016	16.7
	13 20	0006	0.014	
	13 20	0015	0.016	
	13 20	0025	0.019	
	13 20	0035	0.016	
	13 20	0049	0.021	
73/07/23	17 30	0000		12.1
	17 30	0025	0.024	
	17 30	0030	0.044	
73/10/01	14 15	0000	0.023	5.2
	14 15	0005	0.024	
	14 15	0015	0.025	
	14 15	0028	0.027	
	14 15	0034	0.191	

STORET RETRIEVAL DATE 76/06/04

340303
41 10 49.0 074 19 43.0 3
GREENWOOD LAKE
34031 NEW JERSEY
013292

11EPALES 2111202
0020 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	14 15	0000	9.0			92	7.70	18	0.040	0.300	0.060	0.004
	14 15	0006	9.0	12.1		95	7.60	18	0.030	0.500	0.060	0.004
	14 15	0016	8.7	12.0		95	7.60	17	0.040	0.500	0.070	0.004
	14 15	0024	8.6	12.0		92	7.60	16	0.030	0.500	0.070	0.010
73/07/23	17 05	0000	26.2	8.8	100	93	7.60	19	0.070	0.700	0.040	0.000
	17 05	0005	25.9			94						
	17 05	0010	25.8			93						
	17 05	0015	25.4	4.2		92	7.10	19	0.060	0.500	0.040	0.009
	17 05	0020	25.2	7.0		90	6.30	20	0.070	0.500	0.050	0.007
	17 05	0025	17.6			80						
	17 05	0028	14.5	1.2		80	6.30	21	0.170	0.500	0.040	0.007
73/10/01	14 40	0000	19.7		105	190	6.70	12	0.040	0.600	0.020	0.008
	14 40	0005	19.5	8.4		180	6.50	12	0.030	0.400	0.010	0.005
	14 40	0015	19.5	8.2		190	6.60	13	0.030	0.400	0.020	0.005
	14 40	0024	19.1	6.8		180	6.40	11	0.050	0.500	0.020	0.005

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	14 15	0000	0.016	16.4
	14 15	0006	0.017	
	14 15	0016	0.018	
	14 15	0024	0.018	
73/07/23	17 05	0000	0.022	9.9
	17 05	0015	0.025	
	17 05	0020	0.023	
	17 05	0028	0.035	
73/10/01	14 40	0000	0.021	5.1
	14 40	0005	0.019	
	14 40	0015	0.021	
	14 40	0024	0.056	

STORET RETRIEVAL DATE 76/06/04

340304
41 09 14.0 074 20 38.0 3
GREENWOOD LAKE
34031 NEW JERSEY
013292

11EPALES 2111202
0006 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/04/16	15 50	0000	9.4	12.0	60	95	7.60	20	0.070	0.500	0.050	0.011
73/07/23	14 45	0000	26.4		60	94	7.20	21	0.060	0.900	0.040	0.011
	14 45	0005	25.7	7.6		94	6.90	21	0.060	0.600	0.040	0.009
73/10/01	15 05	0000	19.7	9.4	54	180	6.80	15	0.040	0.800	0.020	0.010

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/04/16	15 50	0000	0.021	10.5
73/07/23	14 45	0000	0.040	20.6
	14 45	0005	0.043	
73/10/01	15 05	0000	0.033	10.3

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/06/04

3403A1
41 09 35.0 074 19 50.0 4
WANAQUE RIVER
34 7.5 GREENWOOD LK
O/GREENWOOD LAKE 013292
CO RD 153 BRDG NW OF AWOSTING
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	13 15		0.030	0.450	0.084	0.007	0.030
73/08/26	10 30		0.089	0.600	0.110	0.029	0.035
73/09/23	11 00		0.078	2.000	0.960	0.007	0.035
73/11/04	11 00		0.010K	0.650	0.020	0.005K	0.025
73/12/08	11 00		0.048	0.800	0.068	0.005K	0.055
74/01/26			0.240	0.200	0.025	0.010	0.010
74/02/23	11 00		0.120	0.400	0.015	0.005K	0.022
74/03/23	09 30		0.060	0.500	0.025	0.010	0.037
74/04/21	10 30		0.004	0.450	0.020	0.005K	0.035
74/05/12	11 00		0.112	0.100	0.040	0.020	0.060
74/06/22	11 00		0.016	0.500	0.025	0.005	0.065

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/06/04

340381
41 09 10.0 074 20 59.0 4
BELCHER CREEK
34 7.5 GREENWOOD LK 013292
I/GREENWOOD LAKE
CO RD 511 BRDG JUST ABOV MOUTH
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	12 40		0.020	0.560	0.110	0.005K	0.020
73/08/26	10 00		0.035	0.560	0.042	0.013	0.040
73/09/29	10 00		0.220	1.320	0.260	0.011	0.080
73/11/04	10 00		0.042	0.750	0.025	0.010	0.060
73/12/08	10 00		0.140	0.300	0.032	0.008	0.055
74/01/26	10 30		0.310	0.400	0.040	0.015	0.015
74/02/23	10 00		0.336	0.400	0.035	0.005	0.030
74/03/23	10 00		0.192	0.300	0.030	0.010	0.025
74/04/21	09 30		0.116	0.500	0.045	0.005	0.010
74/05/12	10 00		0.168	0.500	0.050	0.010	
74/06/22	10 00		0.124	0.600	0.128	0.010	0.055

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/06/04

3403C1
41 13 10.0 074 17 28.0 4
UNNAMED CREEK
34 7.5 GREENWOOD LK
T/GREENWOOD LAKE 013292
2NDRY RD BRDG IN GREENWOOD LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/07/21	13 00		0.154	0.880	0.189	0.019	0.090
73/08/26	10 15		0.410	2.100	0.132	0.019	0.030
73/09/23	10 30		0.010K	0.880	0.063	0.005K	0.015
73/11/04	10 50		0.036	0.650	0.015	0.007	0.025
73/12/08	10 30		0.330	0.500	0.036	0.008	0.060
74/01/26	10 45		0.520	0.900	0.190	0.025	0.055
74/02/23	10 30		0.860	1.300	0.045	0.010	
74/03/23	10 30		0.352	0.200	0.020	0.005K	0.010
74/04/21	10 00		0.132	1.300	0.025	0.015	0.100
74/05/12	10 30		0.044	0.480	0.017	0.005	0.045
74/06/22	10 30		0.032	0.300	0.040	0.005	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/06/04

34038A AS34038A P000260
41 08 10.0 074 22 05.0 4
BIRCH HILL PARK DISPOSAL COMPANY
34 7.5 GREENWOOD LK
T/GREENWOOD LAKE 013292
BELCHER CREEK
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/01/02	09 40		0.600	41.000	16.000	2.900	7.700		
74/02/21	10 00		0.800	33.000	12.500	3.700	9.450		
74/03/06			0.680	40.000	15.000	3.150	4.400	0.008	0.010
74/04/17			0.640	30.000	13.500	3.000	8.700		
74/05/15			0.480	25.000	8.200	2.400	6.800		
74/06/04			0.200	46.000	18.800	5.900	11.000		
74/07/17	08 35		0.160	45.000	0.050K	1.600	10.500	0.008	
74/08/14			0.400	44.000	13.000	4.300	9.450		
74/09/11			0.160	43.000		4.750	10.500		
74/10/16			0.300	14.000	3.600	1.800	3.600		
74/11/13			1.680	18.000	4.000	2.100	4.400		
74/12/10			0.480	20.750	5.500	1.380	6.250		
75/01/09			0.320	2.800	0.590	0.270	0.320		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/06/04

3403XA SF3403XA P000160
41 08 15.0 074 22 05.0 4
MARSHALL HILL SCHOOL
34 7.5 GREENWOOD
T/GREENWOOD LAKE 013292
MORESTOWN BROOK TO BELCHERS CREEK
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
74/01/02	09	50	11.200	1.000	0.100	1.920	2.000		
74/02/21			3.900	1.000K	0.150	0.340	6.700		
74/03/06			8.400	4.900	0.150	1.800	2.100		
74/04/17			19.000	1.000K	0.120	2.400	2.450		
74/05/15			6.700	1.000K	0.050K	0.950	0.980		
74/06/04			46.000	1.000K	0.050K	3.850	5.000		
74/09/11	08	17	15.800	1.000	0.100	2.800	3.000	0.007	
74/10/16			51.200	1.000K	0.140	2.300	2.500		
74/11/13			23.200	1.000K	0.050K	2.100	2.200		
74/12/10			18.400	5.200	0.065	2.600	3.600		
75/01/16	10	30	16.800	6.700	0.055	3.000	3.800		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1973

STATE OF NEW JERSEY

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3402	BUDD LAKE	0.082	0.205	474.000	48.500	7.400	0.012
3403	GREENWOOD LAKE	0.021	0.100	414.250	11.920	14.800	0.007
3406	ORADELL RESERVOIR	0.055	0.990	462.500	22.267	13.600	0.008
3409	PINECLIFF LAKE	0.070	0.175	465.500	38.960	11.000	0.011
3410	POMPTON LAKES	0.071	0.795	463.167	23.033	11.800	0.029
3412	DUHERNAL LAKE	0.082	1.420	466.667	6.800	8.600	0.010
3413	FARRINGTON LAKE	0.055	0.770	462.000	8.283	14.400	0.012
3415	LAKE HOPATCONG	0.022	0.120	416.333	13.627	14.900	0.007
3417	LAKE MUSCONETCONG	0.036	0.140	436.000	11.067	6.000	0.010
3419	PAULINS KILL LAKE	0.133	0.950	460.500	7.017	9.000	0.065
3420	SPRUCE RUN RESERVOIR	0.020	0.470	428.667	15.333	15.000	0.007
3422	UNION LAKE	0.063	1.150	463.200	22.080	12.800	0.018
3423	WANAQUE RESERVOIR	0.014	0.120	355.333	7.111	14.800	0.005

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3402	BUDD LAKE	12 (1)	58 (7)	0 (0)	0 (0)	92 (11)	29 (3)	191
3403	GREENWOOD LAKE	83 (10)	100 (12)	92 (11)	58 (7)	21 (2)	83 (9)	437
3406	GRADELL RESERVOIR	54 (6)	17 (2)	42 (5)	25 (3)	42 (5)	67 (8)	247
3409	PINECLIFF LAKE	33 (4)	67 (8)	17 (2)	8 (1)	67 (8)	42 (5)	234
3410	POMPTON LAKES	25 (3)	33 (4)	33 (4)	17 (2)	58 (7)	8 (1)	174
3412	DUHERNAL LAKE	12 (1)	0 (0)	8 (1)	100 (12)	83 (10)	58 (7)	261
3413	FARRINGTON LAKE	54 (6)	42 (5)	50 (6)	75 (9)	33 (4)	29 (3)	283
3415	LAKE HOPATCONG	75 (9)	87 (10)	83 (10)	50 (6)	8 (1)	83 (9)	386
3417	LAKE MUSCONETCONG	67 (8)	75 (9)	67 (8)	67 (8)	100 (12)	50 (6)	426
3419	PAULINS KILL LAKE	0 (0)	25 (3)	58 (7)	92 (11)	75 (9)	0 (0)	250
3420	SPRUCE RUN RESERVOIR	92 (11)	50 (6)	75 (9)	42 (5)	0 (0)	83 (9)	342
3422	UNION LAKE	42 (5)	8 (1)	25 (3)	33 (4)	50 (6)	17 (2)	175
3423	WANAQUE RESERVOIR	100 (12)	87 (10)	100 (12)	83 (10)	21 (2)	100 (12)	491

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3423	WANAQUE RESERVOIR	491
2	3403	GREENWOOD LAKE	437
3	3417	LAKE MUSCONETCONG	426
4	3415	LAKE HOPATCONG	386
5	3420	SPRUCE RUN RESERVOIR	342
6	3413	FARRINGTON LAKE	283
7	3412	DUMERNAL LAKE	261
8	3419	PAULINS KILL LAKE	250
9	3406	ORADELL RESERVOIR	247
10	3409	PINECLIFF LAKE	234
11	3402	BUDD LAKE	191
12	3422	UNION LAKE	175
13	3410	POMPTON LAKES	174